lowed by the publication of his Philosophy of Storms, Boston, Mass., 1842, after which he was appointed meteorologist to the United States Government and was assigned to duty, first in the War Department, afterward to the Navy Department, and eventually under the Smithsonian Institution. In 1836 he organized a joint committee of the American Philosophical Society and the Franklin Institute for the purpose of studying storms. This work was continued when he removed to Washington, D. C. Observations were gathered and numerous maps constructed, and extensive selections from these were published in his four successive reports, 1845–1860. While Espy dwelt especially on the mechanical theory of the development of storms, Redfield devoted himself to the collection of data illustrating the phenomena, and especially the general movement, of storm centers over the ocean. The general tendency of these two investigators was to establish the fact that individual features of the weather, as well as the storms, as a whole, move over the globe in such a manner that their arrival at any place can be predicted if we have at hand a series of maps showing their movement during the preceding few days. The spread of the electric telegraph throughout the United States during the years preceding 1848 suggested the possibility of compiling such weather maps regularly every day, and the first one was made, as a sample, for Prof. Joseph Henry, by Mr. J. J. Jones, of New York, in that year; but it was not until the next year that Professor Henry obtained from the telegraph companies a general concession for the free use of the telegraph lines for scientific purposes. Daily maps were made, for personal study, from that time forward for several years, and a large wall map, showing the condition of the weather day by day, began to be publicly displayed in the Smithsonian building from 1856 onward. This map was made the basis of frequent special predictions of the weather for the benefit of members of Congress and others who consulted Professor Henry. The success of these predictions furnished a strong argument for the establishment of a general weather service by the Government; but this was not effected until the demand for it came, not from the scientific meteorologists, but from the business interests of the country. In 1868 the Director of the Cincinnati Observatory was, at his own suggestion, authorized by the Cincinnati Chamber of Commerce to organize, at its expense and for the benefit of the merchants of that city, a system of daily weather reports and predictions. After this was done and in successful operation, the work was brought to the attention of the National Board of Trade, meeting at Richmond, Va., in November, 1869, and that body favorably indorsed a general memorial to Congress on behalf of all the commercial interests of the country. This memorial was prepared by Prof. I. A. Lapham and H. E. Payne, both of Milwaukee, Wis. The resulting joint resolution and the act signed by the President February 9, 1870, authorized the Secretary of War to establish a system of telegrams and reports for the benefit of commerce. This military service was transferred to the Department of Agriculture in July, 1891, and its duties were extended so as to include agriculture and all other interests affected by the weather.

When we compare among themselves the daily weather maps showing actual observations carefully made all over the country and presenting, as it were, a photograph of the atmospheric conditions twice or three times a day, one must be impressed with the fact that the predictions of the weather published by the Weather Bureau are based upon a solid foundation of facts and that its methods are radically opposed to those of the local weather prophets and the astrologers.

THE DRIFT OF THE GULF STREAM NEAR KEY WEST, FLA.

The Weather Bureau observer at Key West, Fla., Mr. W. U. Simons, communicates to the Chief of the Weather Bureau a card found in a well-sealed bottle in shallow water, half a mile east of Saddle Bunch Channel and about 12 miles north of east from Key West, about noon May 31. This card contained a notice to the effect that the bottle was deposited in the sea on April 18, in latitude 24° 18′ N. and longitude 84° 25′ W. The point of deposit was therefore about 150 miles distant, and west-southwest of Key West.

In accordance with the general policy of the Weather Bureau, the card picked up by our observer has been forwarded to the Hydrographic Office, United States Navy.

ECLIPSE SHADOW BANDS AND CORRELATED ATMOSPHERIC PHENOMENA.

The following note was prepared by the Editor for publication in 1887, and may still be of interest:

Meteorology has perhaps not much to expect from observations of the barometer and the wind during a total solar eclipse, but it has considerable interest in the shadow bands. It seems quite plausible that the explanation of these is to be found in the interference of two pencils of sunlight that have respectively passed through adjacent portions of air of slightly different densities. This should not be called a diffraction phenomenon, though it does occur when a thin sheet of light from the edge of the sun passes the edge of the moon at the moment preceding totality. Undoubtedly such a slender beam of light may cause diffraction phenomena, but if so, the diffraction bands would necessarily move onward over the earth's surface with the same relative speed as that of the moon and the earth, namely, approximately a mile a second, whereas the observed shadow bands have a velocity of only a few feet or yards per second. On the other hand, the bands may be considered as phenomena of interference of rays of light slightly inclined by reason of the irregular refractions in a nonhomogeneous atmosphere, and they must therefore have such characteristics as are impressed upon them by the condition of the atmosphere at the time; their horizontal movement must correspond nearly with that of the winds and upper currents in the atmosphere. In fact, we need not necessarily speak even of interference phenomena. Every small mass of descending dense air constitutes a rough sort of lens or prism, the beam of light that passes through it must be deflected and the atmospheric mass casts a shadow on the ground, like a lens or prism of glass. Such phenomena may be seen when the air is very much disturbed even in ordinary full sunlight but become much better defined when the sun's disk is reduced to a slender crescent, as during the few seconds preceding and following totality. If there be no small masses of rising hot and descending cold air, but if we conceive the layers of the atmosphere to have definite horizontal surfaces thrown into waves, then the refraction of the light as it passes through these waves would certainly produce beams of light having slight inclinations to each other, which would produce shadows and interferences when they intersect. All interference phenomena in sunshine under favorable circumstances give rise to bands of color rather than alternate bands of darkness and brightness. We are, therefore, inclined to speak of the shadow bands as really shadows produced by the irregular refractions of the atmosphere rather than as pure interference phenomena, although they may partake of the character of both, but they certainly have not the characteristics of diffraction bands, properly so called. Similar shadows contribute materially to the rather complex phenomena of twinkling or scintillation. When a very bright star is observed near the horizon, it not only flickers as to color and brightness, but actually disappears momentarily, due to the fact that its light is refracted so far away from the eye that none of it enters the pupil. The shadow bands that are seen when an electric arc light throws the shadow of a flame and its stream of hot air upon a white wall, are therefore quite analogous to those seen during total eclipses. In fact, it might be possible to exactly reproduce the eclipse shadow bands by causing the shadow of the edge of a disk or wall to fall upon a white surface placed at a great distance therefrom, were it not that streams of hot air from the illuminated sides of the wall are apt to overpower the more delicate atmospheric effect that we desire to observe.

When the sun is near the zenith the horizontal movements of the shadow bands must be due merely to the horizontal movement of the atmosphere carrying the warm and cold masses along with it. When the sun is near the horizon then the vertical motion of the shadow bands is principally the result of the vertical motion of the ascending warm or descending cool masses throughout the atmosphere, while the horizontal movement of the shadow bands depends upon the direction of the wind and the bearing of the sun from the observer. In general, the motion of the shadow band on a horizontal surface can be expressed by simple trigonometric formulæ.

The fact that the atmosphere is a mixture of masses of hot and cold air whose movements in the vertical direction are compounded with those of the horizontal wind currents, gives rise to a number of phenomena that interest the meteorologist, among which I may enumerate the following:

1. The scintillation or twinkling of the stars, which is explicable as due to the refractions, dispersions, and occasional interferences of slender pencils of starlight.

2. The jumping and oscillation of the images of the stars and other celestial objects; this constitutes the "bad seeing" or "bad images" of the astronomers.

3. The extinction or absorption of starlight diminishes with increasing altitude of a star above the horizon and depends partly upon gaseous absorption, partly on the obstacles encountered, such as dust and particles of vapor haze and cloud, but also on the diffuse refraction and reflection of the pencils of light as they pass through numerous refracting surfaces in the atmosphere.

4. The extinction of sound as it traverses the atmosphere does not proceed according to the simple law of the inverse square of the distance, but much more rapidly. In fact, owing to the refraction of sound and the influence of the wind, it is quite possible for the sound to pass entirely over an observer and be heard a mile further on where the sound wave descends to the ground. These irregularities were investigated by Prof. Joseph Henry, on behalf of the Lighthouse Board of the United States, and by Prof. John Tyndall, on behalf of the Trinity House of London. Tyndall seems to have shown that in many cases the mixture of hot and cold masses of air renders the atmosphere as opaque to sound as the mixture of water and bubbles of air is opaque to light. The rapid extinction of sound is due to irregular refractions of sound waves in passing through many small regions of varying densities. Often, in fact, we need not many, but merely one or two changes of density. Thus, a cold wind penetrating a mass of warm air acts as a wall, reflecting and refracting the sound wave into directions entirely different from that which it originally had.

5. The numerous photographs of lightning flashes often show great variations in the width and character of different portions of a flash; sometimes the flash appears like a band or ribbon seen edgewise in one portion and frontwise in another. These features may in part be explicable as due to the irregular refractions in the air between the flash and the camera; in fact, if the flash suddenly heats the air in its track so as to produce an explosion, the irregularities of the refraction will be greatly accentuated.

6. We apparently meet with similar irregularities in the study of the sun. Thus, the instantaneous photographs of the whole sun taken by Janssen in 1877 usually show a few regions where the fine regular structure known as "rice grains" suddenly becomes blurred. These spots I have always attributed to the irregularities of the refraction of light in our own atmosphere and not to similar irregularities in the solar atmosphere, although such undoubtedly exist. The latter could only have an infinitesimal effect as seen from the earth and would possibly have a more decided effect near the edge than near the center of the sun's disk. In fact, the apparent rice grain structure may itself be in part due to such irregularities in the solar atmosphere. The suggestion that the blurs on the photographs may be due to optical imperfections in the lenses of the telescope, or any part of the photographic apparatus, was made but soon abandoned by Janssen himself.

Since the above was written the astronomers in the pure air of Arizona have investigated the origin of symmetrical bands of light in the diffraction images of stars in the large telescopes, and have attributed these bands to the refractions at wave surfaces in the upper atmosphere and resulting interferences. The forms and movements of the optical bands are supposed to indicate the conditions existing in the upper atmosphere, but this requires further investigation.

STORM WARNINGS ON THE OREGON COAST.

A remarkably severe storm passed over Astoria, Oreg., on Wednesday, May 23. In connection with this storm the Evening Telegram of Portland, Oreg., says:

> Notice of the coming of the gale was received at an early hour by Weather Bureau Observer Johnson, who wired the several lifeboat crews. They immediately started out and warned the fishermen to seek cover. It is believed that Mr. Johnson's warning reached the fishermen in time to prevent greater loss of life, although many perished in spite of it.

Capt. A. L. Hall, of the steamship *Walla Walla*, arrived at Seattle, Wash., May 25; he estimated the velocity of the wind at fully 90 miles per hour; it was a southeast gale with southwest squalls which made the sea very choppy.

This action of the Weather Bureau displayman in personally visiting and warning the fishermen is, of course, an every day occurrence throughout our coasts whenever storms threaten, but it is worth quoting, as illustrating the fact, that throughout the United States, from one extreme to the other, wherever the atmospheric elements threaten life or property, the officials of the Weather Bureau are also on hand to give prompt warning of the impending danger.

INDEX TO THE MONTHLY REPORTS OF THE CALIFORNIA SECTION.

In the May number of the report from California, Mr. McAdie publishes an index to the articles contained in the Climate and Crop Bulletins from January, 1897 to December, 1899, as compiled by Mr. H. E. Smith. This commendable enterprise on the part of Mr. McAdie has already borne good fruit by calling the attention of the Editor, and doubtless others, to articles that had been overlooked. A general index up to date would form an appropriate page in each of the annual volumes of the section reports.

In this connection it may be worth while for each section director to page his monthly numbers continuously during each year, and print a title page with contents and index for the annual volume.